Attorney Docket No. 10739.18.93.1

A COOLING SYSTEM FOR TURBOCHARGED INTERNAL COMBUSTION ENGINE

Related Applications

This application is related to U.S. Provisional Application No. 60/450,073, filed on February 25, 2003, the entire disclosure of which is hereby incorporated by reference.

This application is related to and claims priority to German Patent Application No. 102 35 189.9, filed on July 26, 2002, the entire disclosure of which is hereby incorporated by reference.

Field of the Invention

The following invention relates to a cooling system. More particularly, the invention relates to a cooling system for a turbocharged internal combustion engine for marine applications, and a turbine casing with an integral exhaust manifold.

Background of the Invention

Turbocharged internal combustion engines for marine applications such as watercraft, boats, or recreational sporting equipment such as personal watercraft are known. In such internal combustion engines, the cooling of exhaust leading components such as the exhaust manifold, the turbine casing, and the exhaust gas turbocharger under adaptation of the special circumstances of operation in water, is performed differently than internal combustion engines intended for use in offshore vehicles. In this manner, the exhaust manifold housing of known internal combustion engines for marine applications have a double-walled housing chamber with a water jacket design. Ocean/lake water is led through the hollow space formed by the double-walled housing chamber for cooling of the exhaust manifold. The separately formed turbine

casing of known internal combustion engines for marine applications is also cooled by means of water-cooling.

Summary of the Invention

According to the present invention, a turbine casing characterized by an exhaust manifold that is formed as a single piece with the turbine casing, and a cooling facility encompassing both the turbine as well as the exhaust manifold is provided. In addition, the invention provides for a turbocharged internal combustion engine defined by a turbine casing with the above characteristics, as well as a method for cooling a turbocharged internal combustion engine where sea/lake water is led through a cooling facility surrounding both the exhaust manifold and the turbine, in order to cool them. Furthermore, the invention provides for cooling the turbine bearings of the turbocharger by providing a separate cooling circuit, whereby coolant is diverted off and led back to the engine cooling circuit.

Therefore, according to the invention, the turbine casing and the exhaust manifold housing are formed together as a single unit, and are surrounded by a common cooling facility. Thus, as an advantage, the interface between the until now separately formed components of the turbine casing and the exhaust manifold housing is no longer required. This has the consequence that on both housings, flanges for the transfer of exhaust gas and coolant between the two housings no longer must be given. Furthermore, the invention saves weight and requires one less sealing location. Particularly, the previously required bolted connection between the exhaust manifold housing and turbine casing, which is subject to extreme stress due to the cyclic thermal growth, is no longer required. Of particular advantage is the possibility to surround both single-piece formed housings by a common cooling facility, preferably a water jacket, which

encapsulates both hot gas-leading areas of the two component housings without interruption through a flange.

Due to the arrangement of the invention, the cooling facility is a cavity, formed by a double wall and filled with coolant, whereby preferably each single bend of the exhaust manifold is provided with a coolant inlet. This feature ensures a symmetrical and even inflow of the coolant in the cooling facility. The coolant outlet is provided further downstream on the turbine so that coolant first flows around the exhaust manifold, then around the turbine, and then exits. For marine applications of the turbocharged internal combustion engine subject to the invention, ocean/lake water is especially suitable as the coolant for the cooling facility.

Due to the improved cooling effect achieved by the invention, it is possible to form a turbine casing with less heat-resistant materials (e. g., low-alloy steel, gray cast iron, aluminum) compared to known turbine casings. These materials have better casting characteristics and are more cost-efficient in comparison to high-alloy steel.

As a particular design advantage of the invention, a separate cooling circuit from the cooling facility of the turbine casing is intended for cooling a bearing housing. This separate cooling circuit preferably branches off from the already given engine cooling circuit. Thus, according to the invention, separate cooling of the turbine casing and the bearing housing takes place, whereby the first is cooled with a very cold coolant; preferably ocean/lake water with a maximum temperature of 30 to 35° C, and the later with a warmer coolant; preferably the coolant from the engine coolant circuit with a temperature generally exceeding 70° C. This feature effects a strong cooling of the turbine casing with "cold" ocean/lake water, and thus decreases the surface temperature of the combined exhaust manifold housing and turbine casing to corresponding limit values given by marine regulations. With the use of the warmer coolant

from the engine coolant circuit for the cooling of the bearing housing the bearing friction is reduced in comparison to cooling with a colder coolant. This results in improved response characteristics and in an improved overall efficiency factor of the turbocharger.

A method for cooling of a turbocharged internal combustion engine for marine applications in accordance with the invention is given by removal of coolant from an engine block, thermostat, cooler and coolant pump - which form the coolant circuit of the engine - for cooling of a turbine bearing from the turbocharger and leading it back into this circuit after cooling the turbine bearing housing and to provide separate cooling for the exhaust manifold and turbine via ocean/lake water, which has been led through a cooling facility surrounding both the exhaust manifold and the turbine. Preferably, the coolant for cooling of the turbine bearing housing is taken from the coolant circuit upstream of the coolant pump and led back into the coolant circuit downstream of the coolant pump.

The aforementioned characteristics and those described in the following can be utilized not only in the combinations mentioned, but also in other combinations or by themselves, within the scope of this invention.

Description of the Drawings

Figure 1 is a cross-sectional view of a combined turbine casing and exhaust manifold according to a preferred embodiment of the present invention.

Figure 2 is a cross-sectional view of the combined turbine casing and exhaust manifold taken along lines II-II of Figure 3.

Figure 3 is a partial cross-sectional view of the combined turbine casing and exhaust manifold in accordance with a preferred embodiment of the invention.

Figure 4 is a perspective view of the combined turbine casing and exhaust manifold of Figures 1 - 3, along with additional components for installation.

Figure 5 is a schematic representation of the coolant flow in a turbocharged internal combustion engine.

Figure 6 is a schematic representation of the engine cooling circuit of a turbocharged internal combustion engine, including the turbine bearing housing cooling circuit.

Detailed Description

Figure 1 show a turbine casing 10 for a turbocharged internal combustion engine for marine applications, characterized by an exhaust manifold 12, 14 which is formed as a single piece with the turbine casing, and a cooling facility 18, 20, 22 encompassing both a turbine 16 as well as the exhaust manifold 12, 14. Additionally, the cooling facility is formed by a double-walled 18, 20 cavity 22, which can be subjected to the admission of coolant. A coolant inlet 28 may be provided for at each single bend 12 of the exhaust manifold, as shown in Figure 3. Also, a coolant outlet 44 may be provided for at the turbine casing, as shown in Figure 4. The cooling medium being used in the cooling facility 18, 20, 22 may be sea or lake water. Furthermore, a bearing housing 32, as shown in Figure 4, for support of a turbine bearing may be provided, for which a cooling circuit separate from the cooling facility 18, 20, 22 of the turbine casing may be used for cooling the bearing housing 32. The invention also contemplates a turbocharged internal combustion engine for marine applications, defined by the preceding characteristics.

As shown in Figure 6, the invention contemplates a method for cooling a turbocharged internal combustion engine for marine applications, whereby an engine block 52 is connected in a cooling circuit 50 with a thermostat 54, a cooler 56 and a coolant pump 58, and for cooling of a turbine bearing housing of the turbocharger for which coolant is diverted off and led back to the

cooling circuit 50, and for which sea/lake water is led through the cooling facility 18, 20, 22 surrounding both the exhaust manifold and the turbine, in order to cool the exhaust manifold 12, 14 and the turbine 16. The cooling medium may be taken from the cooling circuit 50 after the coolant pump 58 and reentered into the coolant circuit 50 again ahead of the coolant pump 58. Furthermore, the sea/lake water may be symmetrically led through each single bend 12 of the exhaust manifold into the cooling facility 18, 20, 22.

Figure 1 shows the turbine casing 10 in accordance with the invention, on which the usually separated components – exhaust manifold housing and turbine casing – are formed as a single piece. The turbine casing 10 in accordance with the invention consists of two single bends 12 (also see Figures 2 and 3) with exhaust gas guide ducts 14 that lead into the turbine 16. It will be appreciated that the present invention can be used with turbine casings that have more than two bends.

The turbine casing 10 in accordance with the invention consists of a double wall 18, 20 which forms the hollow space 22 between the walls 18, 20. In the sectional views of Figures 1 to 3, the hollow space 22 is indicated as a duct that is interrupted by ribs 24, whereby the ribs 24 are the connecting bridges between the two walls 18 and 20 of the double wall.

Coolant, especially ocean/lake water, is admitted to the hollow space 22. For this purpose, a flange 26 with a coolant inlet opening 28 each is provided for in the area of every single bend 12. Both single bends 12 and the coolant inlet openings 28 are preferably formed symmetrical, in order to enable a nearly uniform flow with ocean/lake water.

The ocean/lake water used for cooling, in accordance with the invention, thus flows into the hollow space 22 through the coolant inlet opening 28, whereby the hollow space 22 is formed in such a manner that the water flows evenly around the hot, gas-leading areas. At first, the

ocean/lake water flows around the exhaust gas guide ducts 14 of the two single bends 12 and afterwards around the turbine 16. Only locations in the interior of the turbine casing that cannot be cooled well can, if required, be formed as a cast-in steel insert (instead of solid aluminum).

This steel insert (not shown) can be a finish-cast part, not requiring refinishing and thus cost effective.

In the area of the exhaust gas guide duct 14 in Figure 1, an opening is shown in the worm of the turbine 16, which forms a channel 30 for a bypass-supply (also see Figure 3).

Figure 4 shows a perspective view of the turbine casing in accordance with the invention in the assembly position and with several further components. In particular, Figure 4 shows the bearing housing 32 and a compressor housing 38. Also shown in Figure 4 is a flange 40 on the turbine casing 10 for an exhaust gas pipe 46 (see Figure 5). Provided on the flange 40 are an exhaust gas outlet opening 42 (turbine outlet) and outlet openings 44 of the hollow space 22 through which the ocean/lake water can emerge in order to cool the turbine casing 10. In the shown design example of the invention, ocean/lake water emerges through the outlet openings 44 and is led further in a corresponding double-wall hollow space of the exhaust gas pipe 46, thus also supporting the cooling of the exhaust gas pipe.

For cooling of the bearing housing 32, a coolant circuit is provided in accordance with the invention, as shown in Figure 6. The coolant circuit 50 includes an engine block 52 that is connected with hoses 60 via a thermostat 54 to a cooler 56 and a coolant pump 58.

From the engine cooling circuit 50, coolant, according to the invention, is diverted via an auxiliary line 62 for cooling of the turbine bearing in the bearing housing 32, and afterwards led back into the coolant circuit 50 again. Preferably, this branching-off of coolant is carried out in

front of the coolant pump 58, as indicated in Figure 6, and the return of the coolant into the circuit takes place downstream of the coolant pump 58, ahead of the engine block 52.

The complete coolant path of a turbocharged internal combustion engine in accordance with the invention is represented schematically in Figure 5, whereby the coolant flow is indicated with arrows. Figure 5 shows the engine block 52 with intake manifolds 53 onto which, according to the invention, a turbine casing 10 with two single bends 12 and the corresponding exhaust gas ducts 14 and the turbine 16 connects. An exhaust pipe 46 connects at the exhaust gas outlet opening 42 (see Figure 4). Also arranged on the turbine casing 10 are a bearing housing 32 and compressor housing 38. Exhaust gas exits the engine block 52 into the single bends 12 as indicated by dashed arrows A and flows through the exhaust gas guide ducts 14 into the turbine 16, and from there into the exhaust pipe 46 where they then emit. The flow of the ocean/lake water for cooling of the turbine casing 10 is indicated by arrows S and takes place as described before. Coolant K from the engine cooling circuit as shown by arrows K is led into the bearing housing 32 via a coolant inlet 34 (also see Figures 5 and 6) and led out of the coolant circuit again via a coolant outlet 36.